

# Implementing the International Precipitation Working Group (IPWG) Validation Statistics in Online Tools to Intercompare and Characterize Satellite-derived Global Precipitation Products

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University, USA

<sup>3</sup>ADNET Systems, Inc., USA

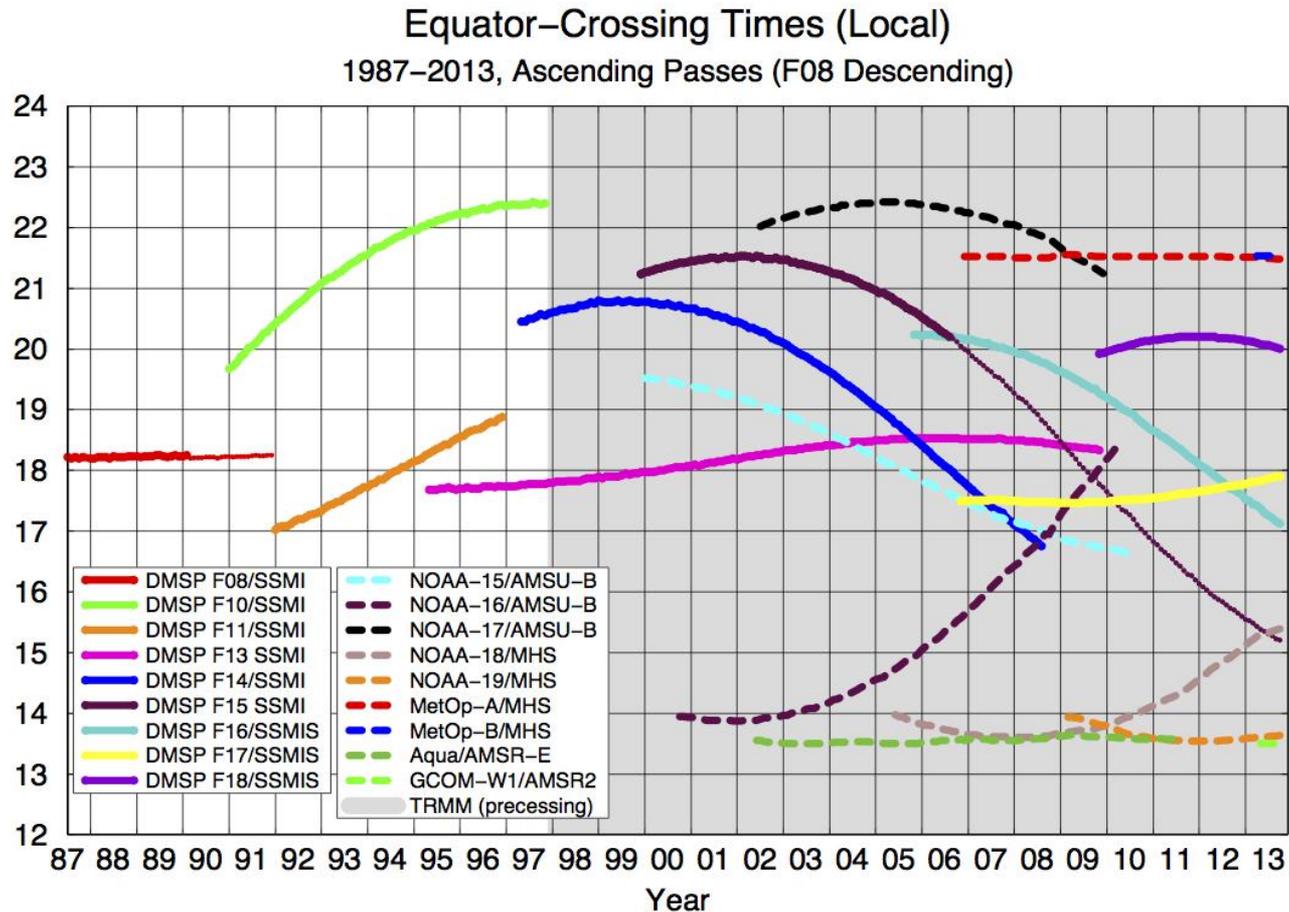
# Outline

- Introduction
- Overview of intercomparison efforts at GES DISC
- Ongoing web tool development (IPWG)
- Summary and URLs
- Future work

# Introduction

- NASA Goddard Earth Sciences Data and Information Services Center (GES DISC) – **TRMM** product archive, data services, documentation and user support

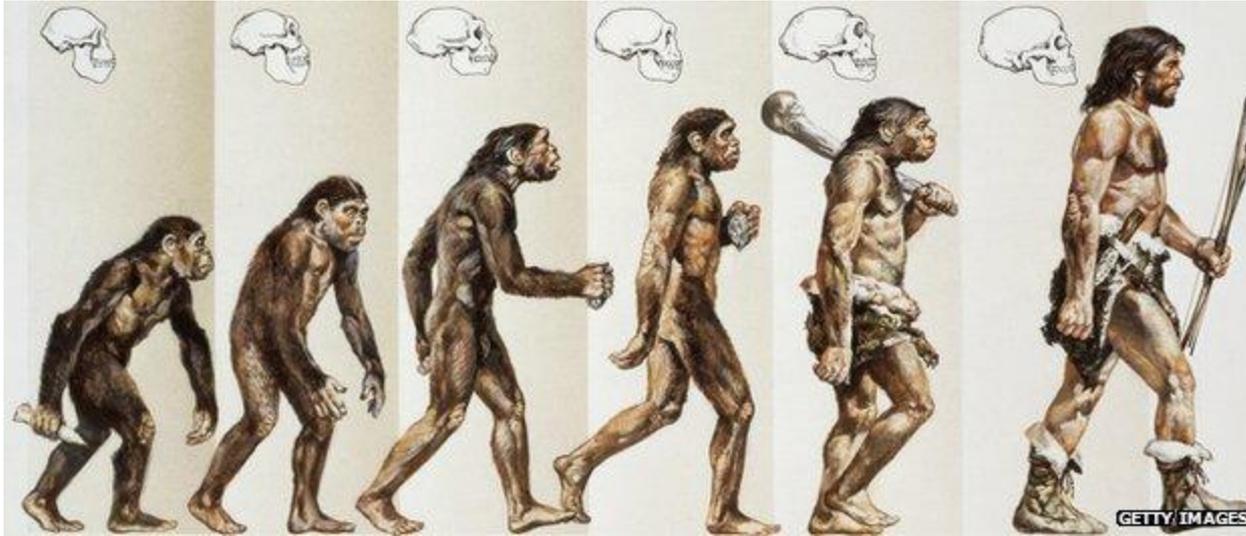
- Product version changes (local and regional)
- Product differences (local and regional)
- Quick view of statistics
- Recommendations during the previous IPWG meetings



# Product A

Version 1

Version N



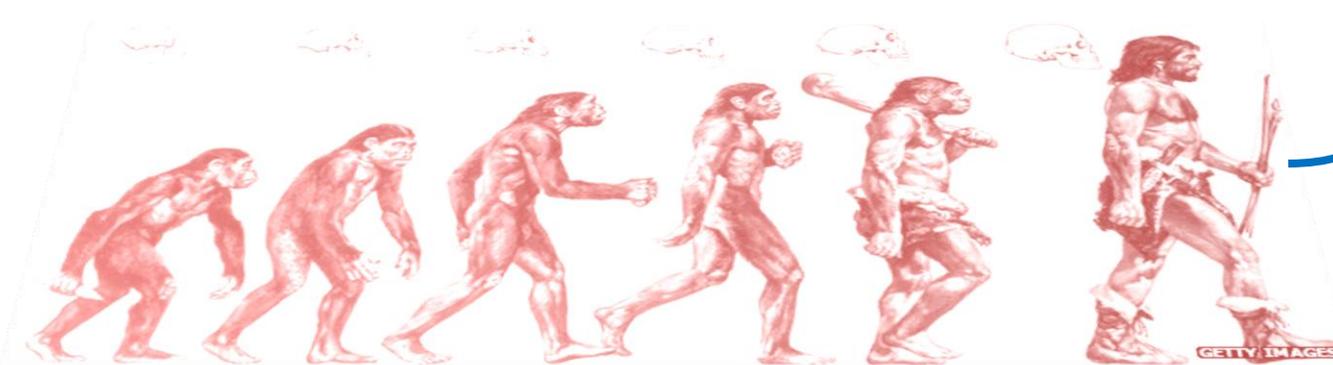
What are the differences?



# Product B

Version 1

Version N



# Intercomparison efforts at GES DISC: Giovanni TOVAS (TRMM Online Visualization and Analysis System)

The screenshot displays the NASA Earth Data website interface. At the top, there is a navigation bar with links for Data Discovery, Data Centers, Community, Science Disciplines, and Search EOSDIS. The main header features the NASA logo, the text 'GES DISC Goddard Earth Sciences Data and Information Services Center', and a search box labeled 'Search GES DISC' with an 'Advanced Search' link. Below the header, there are tabs for 'GES DISC Home', 'Data Services', 'Science Portals', and 'Mission Portals'. Under 'Science Portals', there are sub-tabs for 'Atmos Composition', 'Hydrology', 'Precipitation', 'Ozone', 'MAIRS', and 'More...'. The 'Precipitation' sub-tab is active, showing a background image of clouds. On the left side, there is a sidebar with a table of contents including 'OVERVIEW', 'DATA HOLDINGS', 'DOCUMENTATION', 'Additional Features', 'News', 'Alerts', 'Tools', 'Science Focus', 'Applications', 'Instruments', 'Links', and 'FAQ'. The main content area shows the breadcrumb trail: 'You are here: GES DISC Home > Precipitation > TRMM Online Visualization and Analysis System (TOVAS)'. The title is 'TRMM Online Visualization and Analysis System (TOVAS)'. The introductory text states: 'Welcome to TOVAS, a member of the Giovanni (GES-DISC Interactive Online Visualization AND aNalysis Infrastructure) family, which provides users with an easy-to-use, Web-based interface for the visualization and analysis of global precipitation data.' Below this, there is a section for 'Additional Features' with a list of links: 'Welcome to TOVAS, a member of the Giovanni (GES-DISC (Goddard Earth Sciences Data and Information Services Center) Interactive Online Visualization AND aNalysis Infrastructure) family, which provides users with an easy-to-use, Web-based interface for the visualization and analysis of global precipitation data. See the FAQ for further usage on this tool.' The 'Instances' section includes 'Near-Real-Time Monitoring Product (For research, use Archive Data)' with links for 'Experimental Real-Time TRMM Multi-Satellite Precipitation Analysis (TMPA-RT): 3B42RT', 'Daily Global and Regional Rainfall (3B42RT derived)', 'TMPA-RT Intermediate IR Product: 3B41RT (VAR)', and 'TMPA-RT Intermediate Microwave Product: 3B40RT (HQ)'. The 'Satellite Rainfall Archives' section lists links for 'Monthly Global Precipitation (GPCP)', '3-hourly TRMM and Other Rainfall Estimate (3B42 V7)', 'Daily TRMM and Other Rainfall Estimate (3B42 V7 derived)', and 'Monthly TRMM and Other Data Sources Rainfall Estimate (3B43, 3A12, 3A25 V7)'. The 'Ground Observation Archives' section lists links for 'Monthly Willmott and Matsuura Global Precipitation (1950 - 1999)' and 'Monthly GPCC Rainfall (1986 - Present, Monitoring Product)'. The 'Rainfall Product Intercomparison' section lists links for 'Inter-Comparison of Rainfall Climatology (non-java version)', 'Beta Prototype: Inter-Comparison of TRMM L-3 V6 and V7 Monthly Products', 'Beta Prototype: Inter-Comparison of 3-hourly Precipitation Products', and 'Beta Prototype: Inter-comparison of Daily Precipitation Products'. The 'Climatology' section lists a link for 'TRMM Composite Climatology'. At the bottom, there is a footer text: 'Continued improvement of this online tool, and the production and dissemination of these data sets, depends on your (our users) informing us on how you have used this tool and these data. We'.

**ALERTS**

- ⚠️ 07/09/2012 - Replacement TRMM Data Products for July 6-8th, 2012 (DOY 188-190)  
reported on Jul 09, 2012
- ⚠️ (06/11/2012) PPS TRMM Data Processing Delay (DOY 160)  
reported on Jun 11, 2012
- ⚠️ TRMM V7 3B42 and 3B43 in Mirador Now  
reported on May 31, 2012
- ⚠️ 03/12/2012 - Replacement TRMM 2A12 Data Products for March 08, 2012  
reported on Mar 12, 2012
- ⚠️ 03/12/2012 - Status Update of TRMM 3B42, 3B43  
reported on Mar 12, 2012

**Additional Features**

- + News
- + Alerts
- + Tools
- + Science Focus
- + Applications
- + Instruments
- + Links
- + FAQ

**Instances**

**Near-Real-Time Monitoring Product (For research, use Archive Data)**

- [Experimental Real-Time TRMM Multi-Satellite Precipitation Analysis \(TMPA-RT\): 3B42RT](#)
- [Daily Global and Regional Rainfall \(3B42RT derived\)](#)
- [TMPA-RT Intermediate IR Product: 3B41RT \(VAR\)](#)
- [TMPA-RT Intermediate Microwave Product: 3B40RT \(HQ\)](#)

**Satellite Rainfall Archives**

- [Monthly Global Precipitation \(GPCP\)](#)
- [3-hourly TRMM and Other Rainfall Estimate \(3B42 V7\)](#)
- [Daily TRMM and Other Rainfall Estimate \(3B42 V7 derived\)](#)
- [Monthly TRMM and Other Data Sources Rainfall Estimate \(3B43, 3A12, 3A25 V7\)](#)

**Ground Observation Archives**

- [Monthly Willmott and Matsuura Global Precipitation \(1950 - 1999\)](#)
- [Monthly GPCC Rainfall \(1986 - Present, Monitoring Product\)](#)

**Rainfall Product Intercomparison**

- [Inter-Comparison of Rainfall Climatology \(non-java version\)](#)
- [Beta Prototype: Inter-Comparison of TRMM L-3 V6 and V7 Monthly Products](#)
- [Beta Prototype: Inter-Comparison of 3-hourly Precipitation Products](#)
- [Beta Prototype: Inter-comparison of Daily Precipitation Products](#)

**Climatology**

- [TRMM Composite Climatology](#)

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# Intercomparison efforts at GES DISC: Giovanni TOVAS (TRMM Online Visualization and Analysis System)

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NASA Earth Data Data Discovery Data Centers Community Science Disciplines Search EOSDIS

NASA GES DISC Goddard Earth Sciences Data and Information Services Center Search GES DISC Search Advanced Search

GES DISC Home Data Services Science Portals Mission Portals

Atmos Composition Hydrology Precipitation Ozone MAIRS More...

Precipitation

+ OVERVIEW  
+ DATA HOLDINGS  
+ DOCUMENTATION

**Additional Features**

- + News
- + Alerts
- + Tools
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reported on Mar 12, 2012
- 03/12/2012 - Status Update of TRMM 3B42, 3B43  
reported on Mar 12, 2012

**You are here:** [GES DISC Home](#) > [Precipitation](#) > TRMM Online Visualization and Analysis System (TOVAS)

## TRMM Online Visualization and Analysis System (TOVAS)

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Welcome to TOVAS, a member of the [Giovanni](#) (GES-DISC (Goddard Earth Sciences Data and Information Services Center) Interactive Online Visualization AND aNalysis Infrastructure) family, which provides users with an easy-to-use, Web-based interface for the visualization and analysis of global precipitation data. See the [FAQ](#) for further usage on this tool.

### Instances

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- [TMPA-RT Intermediate Microwave Product: 3B40RT \(HQ\)](#)

#### Satellite Rainfall Archives

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- [3-hourly TRMM and Other Rainfall Estimate \(3B42 V7\)](#)
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- [Beta Prototype: Inter-Comparison of 3-hourly Precipitation Products](#)
- [Beta Prototype: Inter-comparison of Daily Precipitation Products](#)

#### Climatology

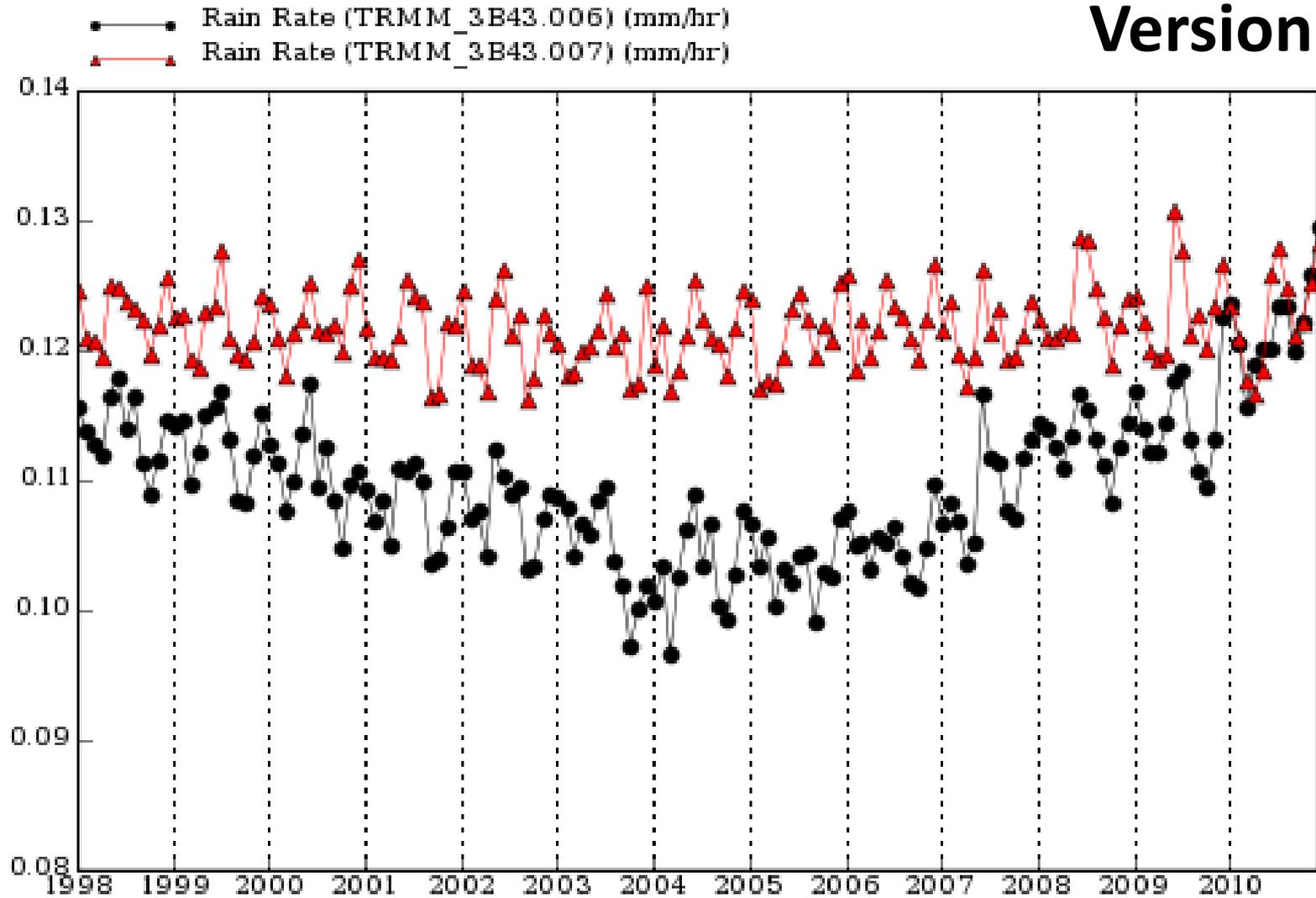
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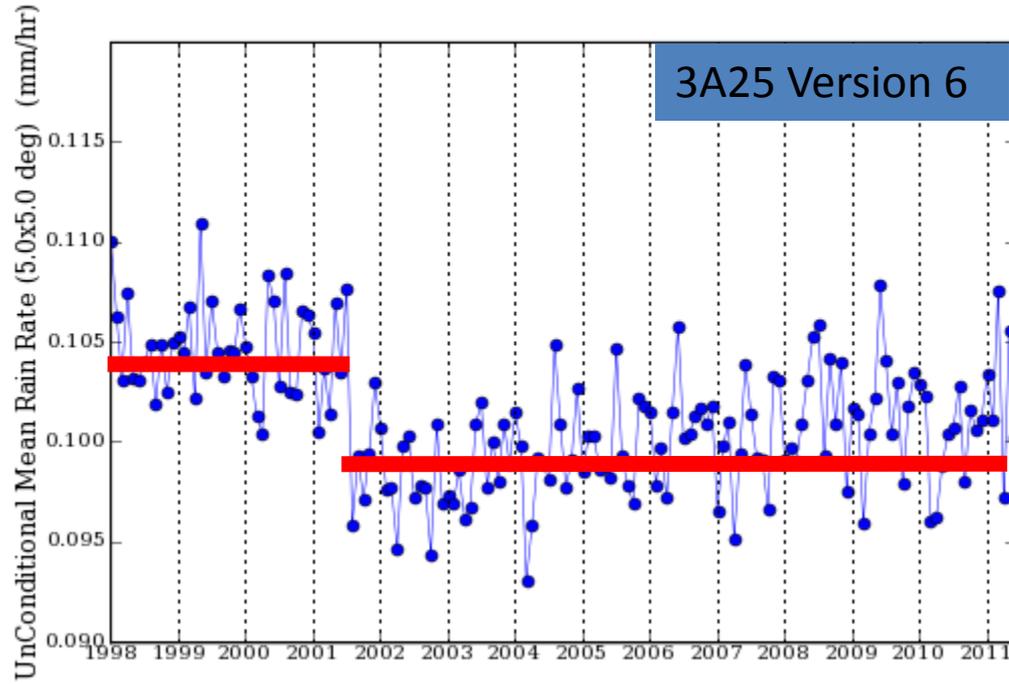
**Version 7**

**Version 6**

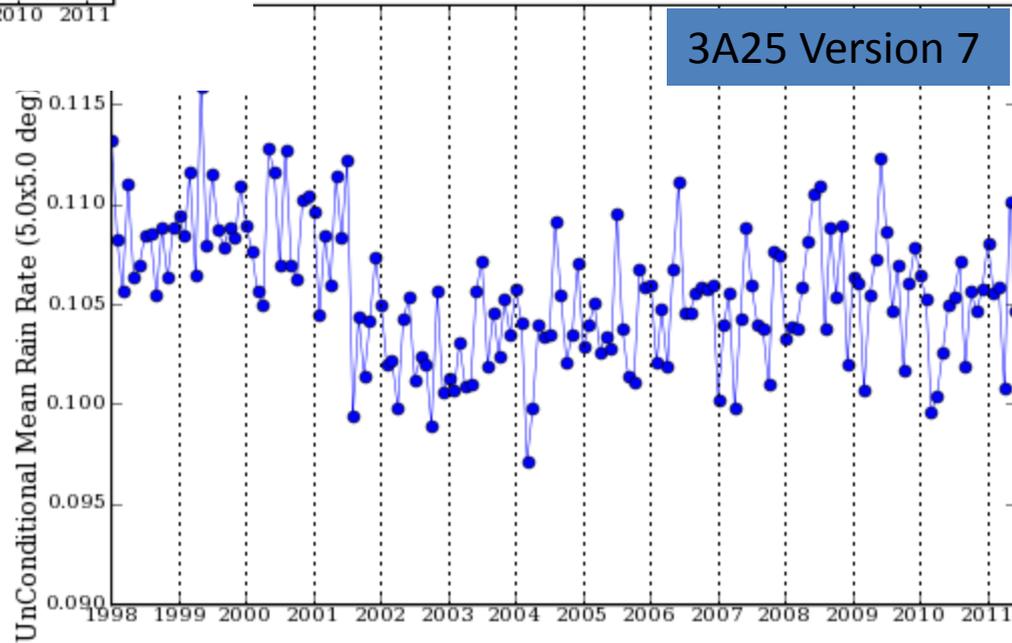
Area-Averaged Time Series  
(Region: 180W-180E, 50S-50N)



Area-Averaged Time Series (TRMM\_3A25.006)  
(Region: 180W-180E, 40S-40N)



Area-Averaged Time Series (TRMM\_3A25.007)  
(Region: 180W-180E, 40S-40N)



TRMM satellite altitude was  
changed from 350 km to 402.5 km  
in August 2001

# Giovanni-4

Improvements over previous Giovanni:

- Omnibus Portal: work with data from different science areas, satellites and time resolutions in one portal
- Interactive Plots: zoom, pan, show values, linked scatter/map
- Order of magnitude speed improvement over previous version
- Seasonal analysis (Beta)
- Vector maps (e.g., wind stress)

Current services in Giovanni-4:

- Time-Averaged map
- Area-Averaged time series
- Map Animation
- Vertical Profile
- Scatterplot comparison
- Interactive scatterplot + map comparison
- Time-Averaged scatterplot comparison
- Correlation map comparison
- Coming soon: Hovmoller

# Giovanni

The Bridge Between Data and Science

v 4.4 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

Version 003 of SeaWiFS Deep Blue Level 3 variables are no longer available... [1 of 2 messages] [Read More](#)

### Select Plot

- Map
- Correlation Map
- Scatter Plot
- Interactive Scatter Plot
- Time-Averaged Scatter Plot
- Time Series
- Vertical Profile

### Select Date Range (UTC)

YYYY-MM-DD

2010 - 06 - 01 00 hrs ▼ to

2010 - 06 - 01 23 hrs ▼

Valid Range: 1997-12-31 to 2011-06-29

### Select Region (Bounding Box)

Format: West, South, East, North

-180, -50, 180, 50

### Select Variables

- ▶ Disciplines
- ▶ Measurements
- ▶ Instruments
- ▶ Platforms
- ▶ Wavelengths
  
- ▶ Spatial Resolutions
- ▶ Temporal Resolutions
- ▶ Portal

Number of matching Variables: 2 of 36

Total Variable(s) included in Plot: 2

Keyword:

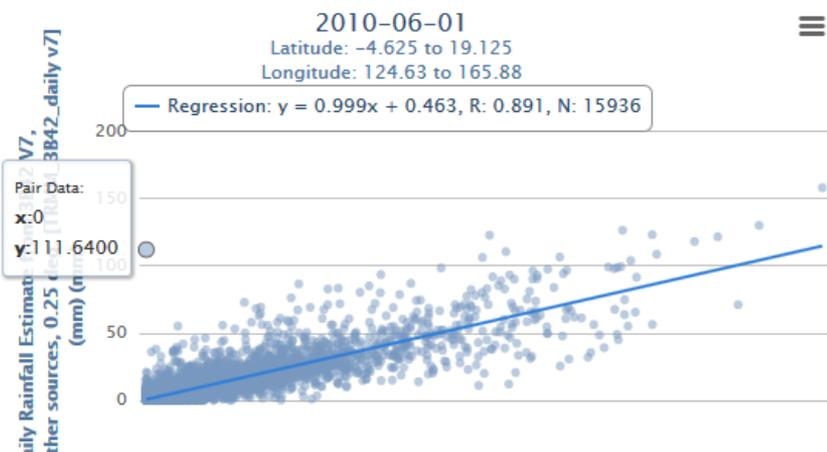
	Variable Name	Vertical Dimension	Resolution	Begin Date	E
<input checked="" type="checkbox"/>	<a href="#">Daily Rainfall Estimate from 3B42 V6, TRMM and other sources, 0.25 deg. [TRMM_3B42_daily_v6]</a>	-	0.25 x 0.25 °	1997-12-31	2
<input checked="" type="checkbox"/>	<a href="#">Daily Rainfall Estimate from 3B42 V7, TRMM and other sources, 0.25 deg. [TRMM_3B42_daily_v7]</a>	-	0.25 x 0.25 °	1997-12-31	2

Version 003 of SeaWiFS Deep Blue Level 3 variables are no longer available... [1 of 2 messages] [Read More](#)

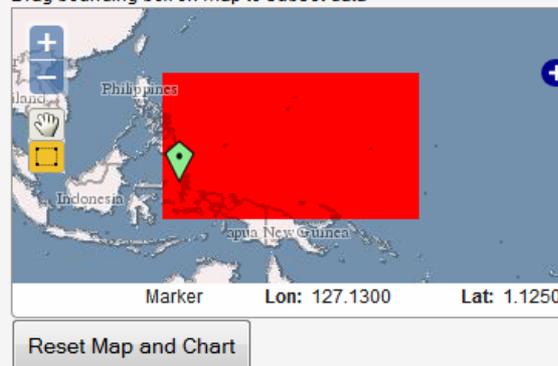
Displaying Result 1 Plots

## Interactive Scatter Plot

Drag bounding box on plot to subset data



Drag bounding box on map to subset data



## History

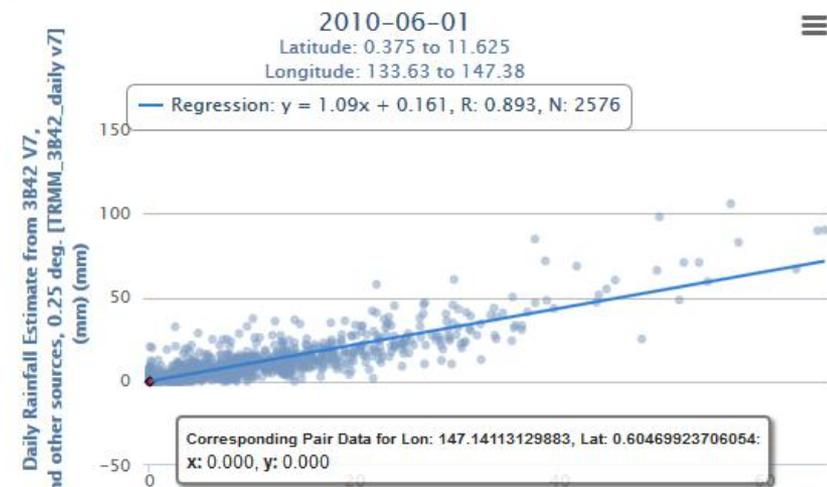
- [Result 1](#)
  - [User Input](#)
  - [Plots](#)
  - [Plot Options](#)
  - [Downloads](#)
  - [Lineage](#)

Version 003 of SeaWiFS Deep Blue Level 3 variables are no longer available... [1 of 2 messages] [Read More](#)

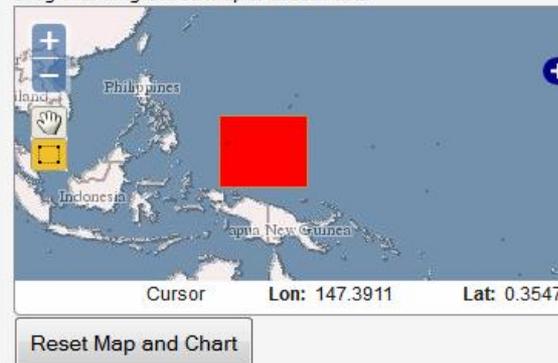
Displaying Result 1 Plots

## Interactive Scatter Plot

Drag bounding box on plot to subset data



Drag bounding box on map to subset data

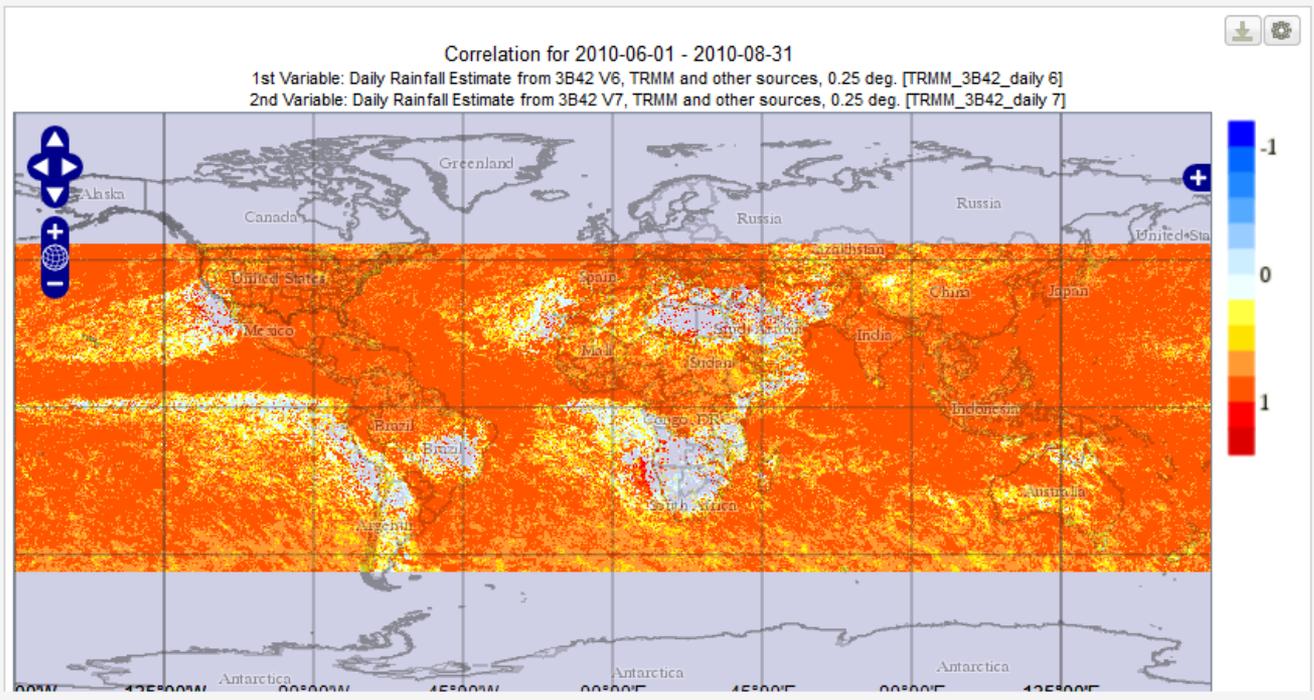


## History

- [Result 1](#)
  - [User Input](#)
  - [Plots](#)
  - [Plot Options](#)
  - [Downloads](#)
  - [Lineage](#)

Version 003 of SeaWiFS Deep Blue Level 3 variables are no longer available... [1 of 2 messages] [Read More](#)

Displaying Result 2 Plots



### History

- [Result 2](#)
  - [User Input](#)
  - [Plots](#)
  - [Plot Options](#)
  - [Downloads](#)
  - [Lineage](#)
- [Result 1](#)
  - [User Input](#)
  - [Plots](#)
  - [Plot Options](#)
  - [Downloads](#)
  - [Lineage](#)



# Ongoing Web Tool Development in NASA GES DISC **Giovanni TOVAS**

-Focus on Adding IPWG Validation  
Algorithms

# Validation / intercomparison of daily satellite precipitation estimates

## -- An IPWG project

<http://cawcr.gov.au/projects/SatRainVal/validation-intercomparison.html>

- Mean Error ✓✓
- Mean absolute error
- Root mean square (RMS) error
- Correlation coefficient ✓✓
- PDF
- Scattplot ✓✓
  
- Hits, misses, false alarms, correct rejections (2x2 contingency table)
- Bias score (ratio of estimated/observed rain frequency or area)
- Probability of detection
- False alarm ratio
- Hanssen and Kuipers score
- Equitable threat score
- Heidke skill score



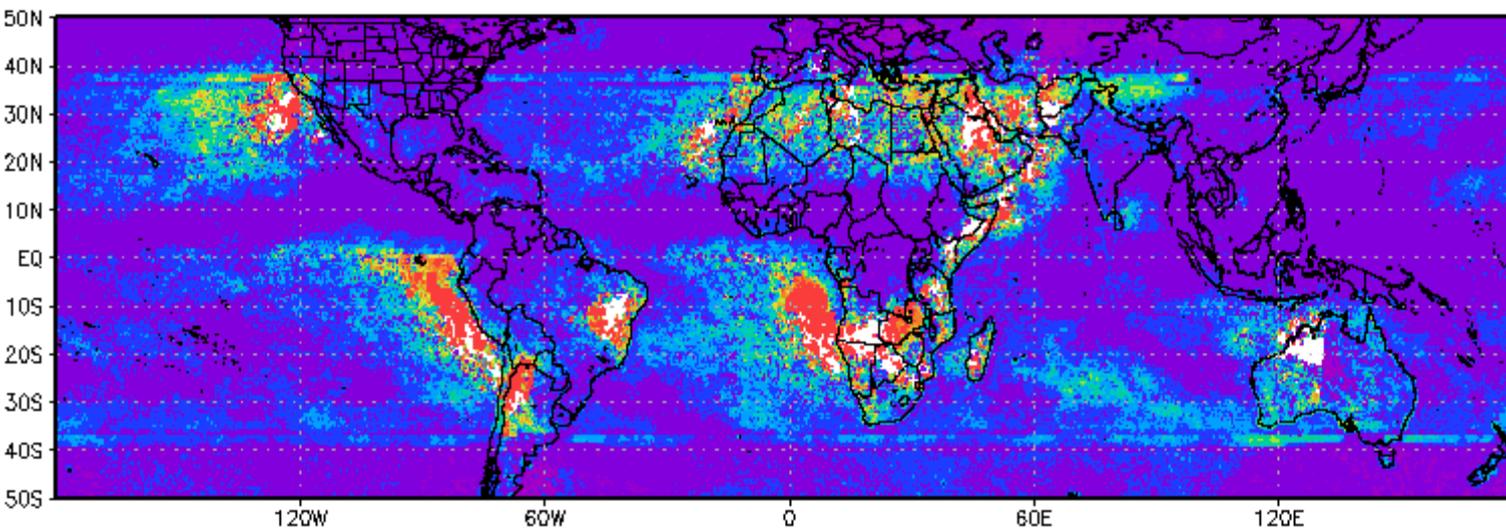
<http://cawcr.gov.au/projects/verification/>

### Contingency Table

Observed

		yes	no	Total
Forecast	yes	<i>hits</i>	<i>false alarms</i>	<i>forecast yes</i>
	no	<i>misses</i>	<i>correct negatives</i>	<i>forecast no</i>
Total		<i>observed yes</i>	<i>observed no</i>	<i>total</i>

## False alarm ratio (JJA 2012)



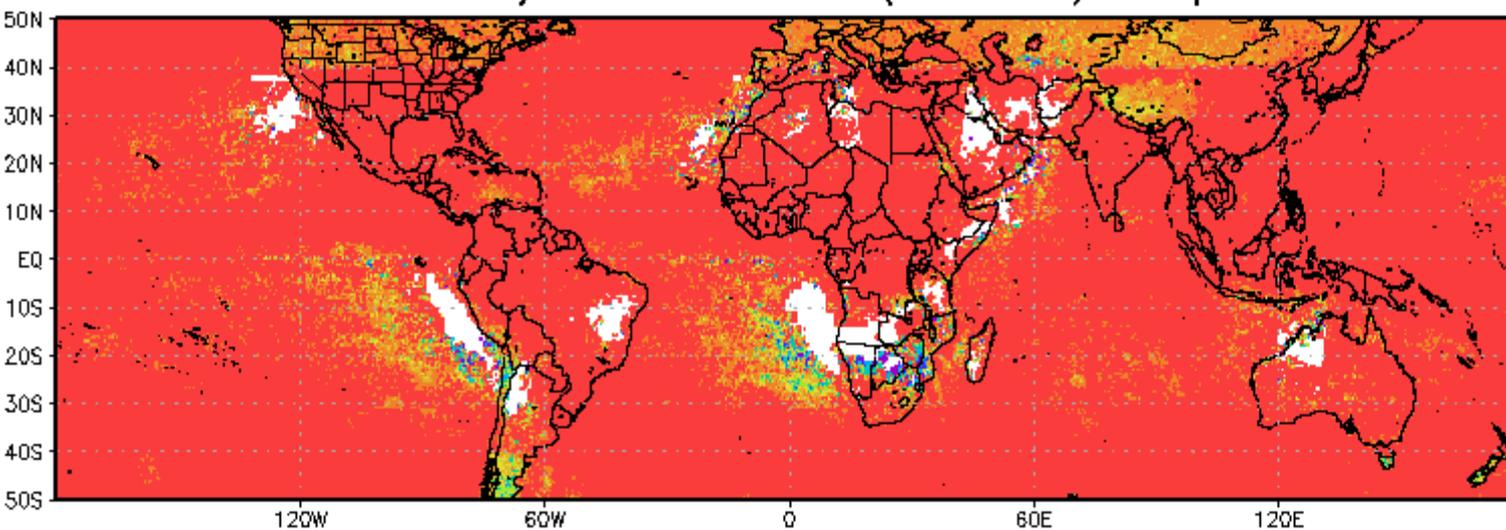
$$FAR = \frac{\text{false alarms}}{\text{hits} + \text{false alarms}}$$

**Range: 0 to 1.**

**Perfect score: 0.**



## Probability of detection (hit rate) or pod (JJA 2012)

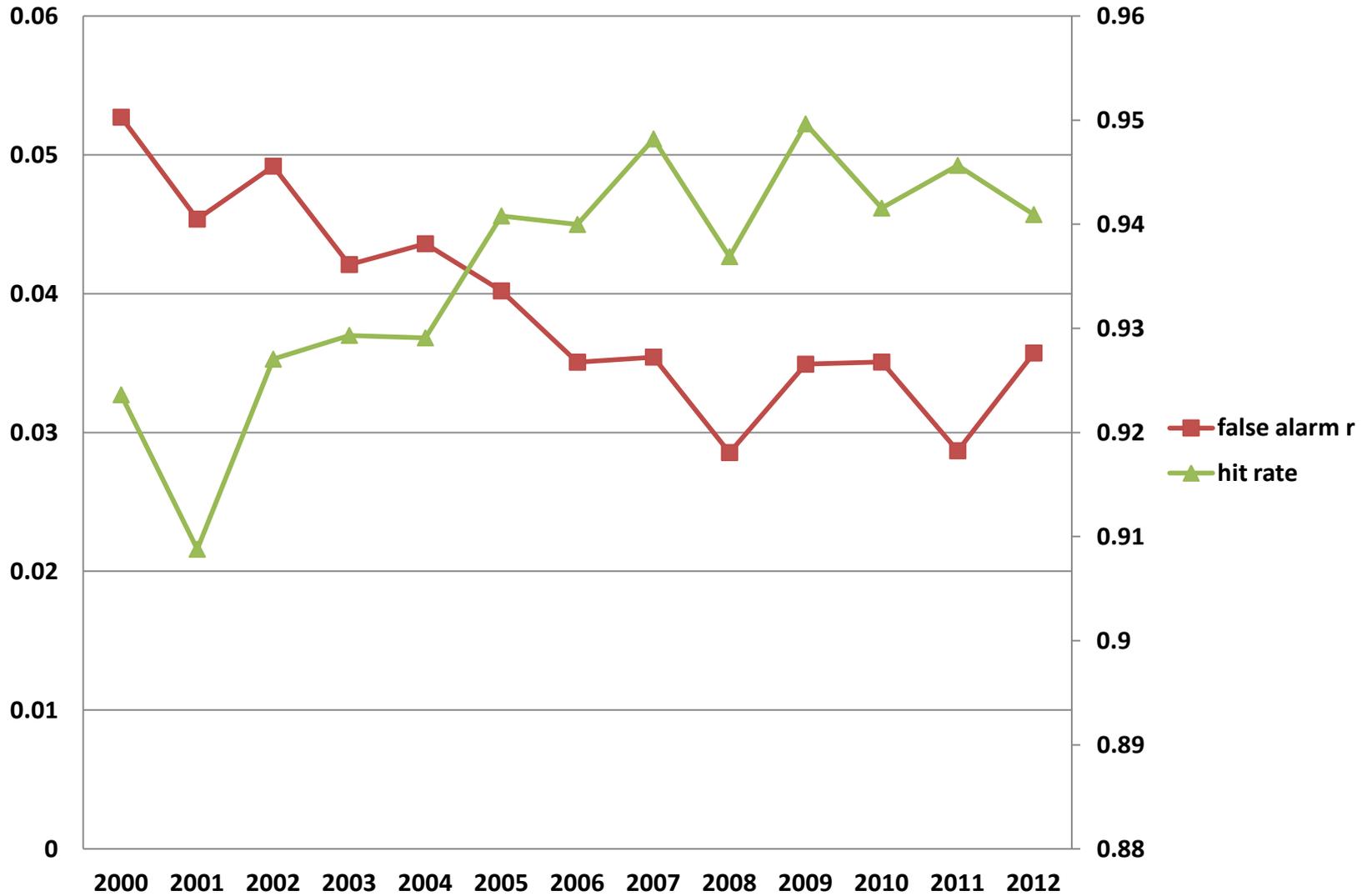


$$POD = \frac{\text{hits}}{\text{hits} + \text{misses}}$$

**Range: 0 to 1.**

**Perfect score: 1.**

### Version 7 3B42RT and 3B42 (JJA NH)

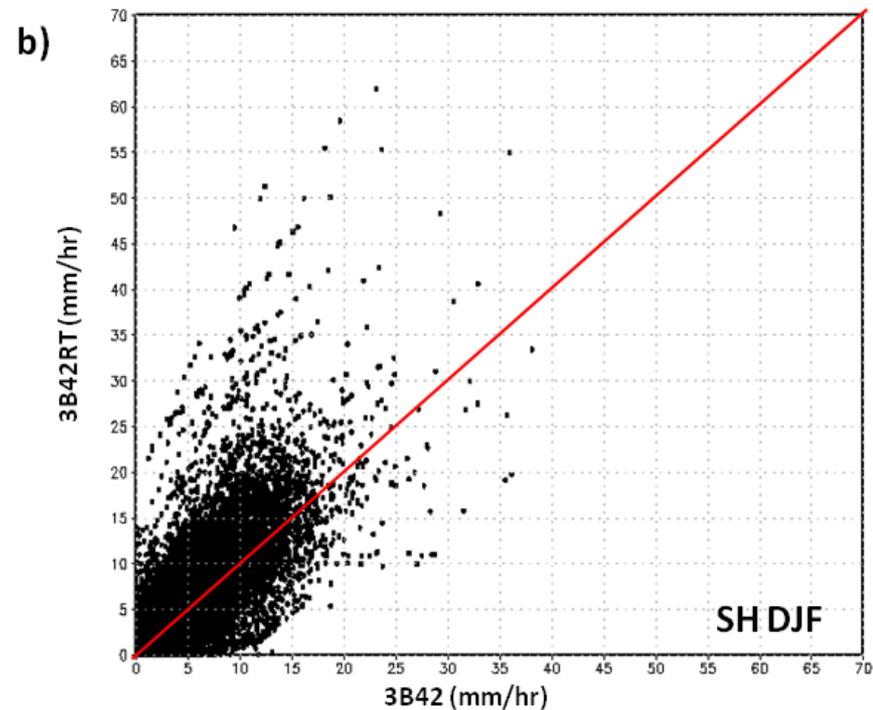
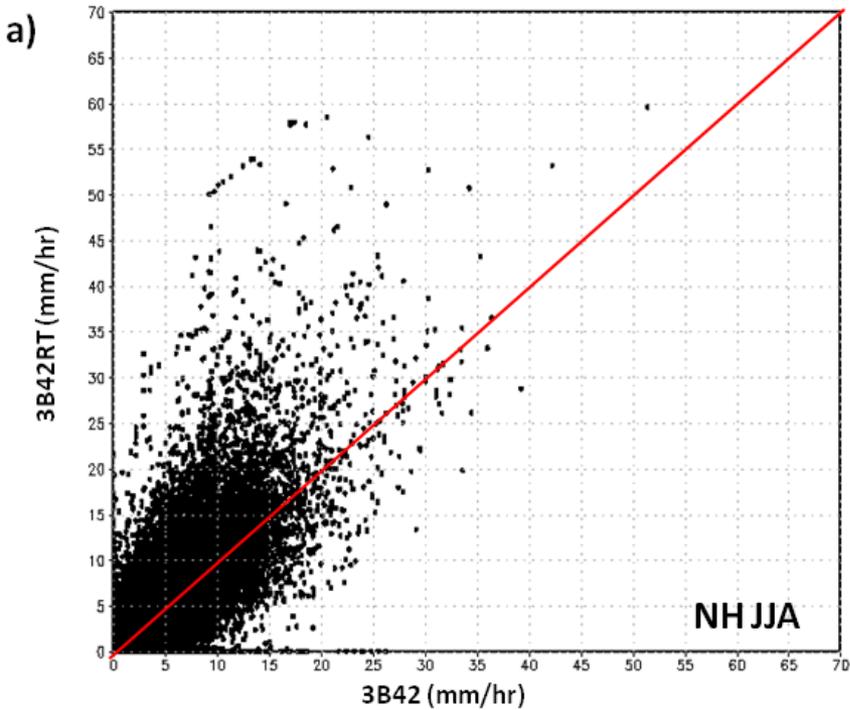




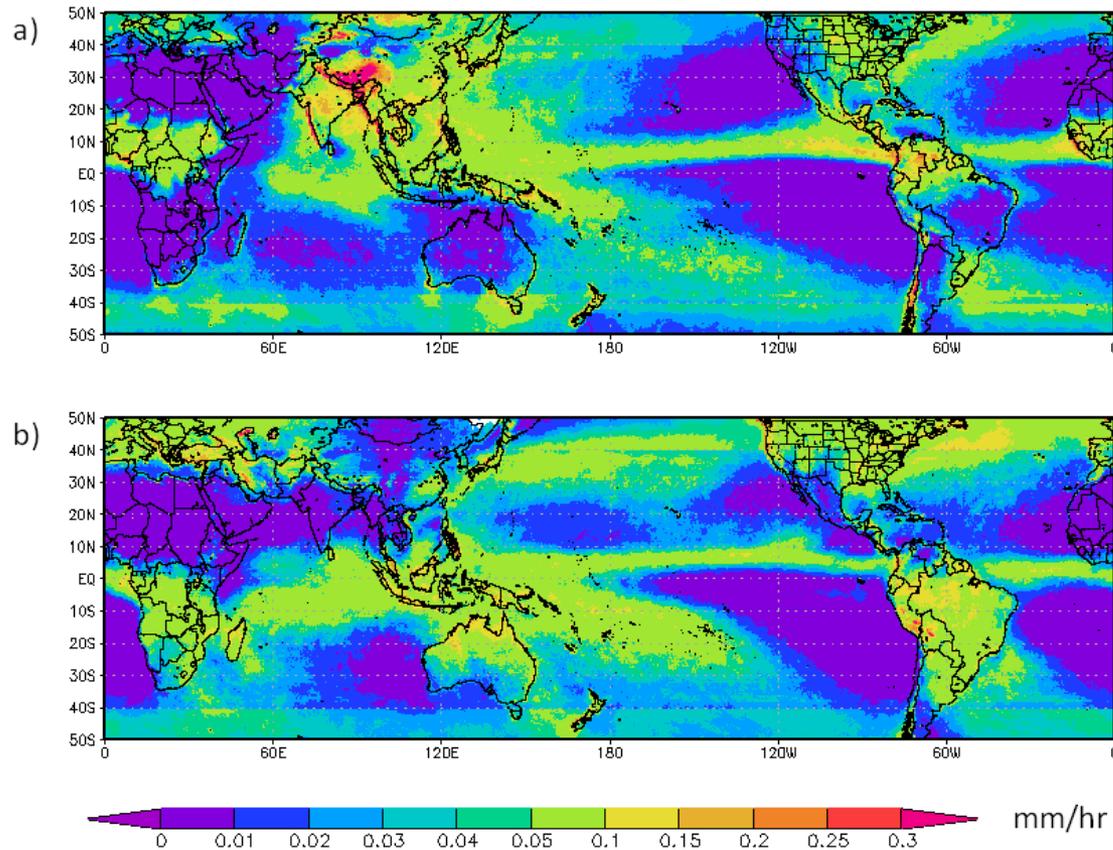
V7 3B42RT vs 3B42

2000 - 2012

Scatter plots between 3B42RT and 3B42 between 2000 and 2012: (a) Northern Hemisphere (JJA); (b) Southern Hemisphere (DJF). The redline is the 1:1 line.



## Mean seasonal MAE for (a) JJA and (b) DJF

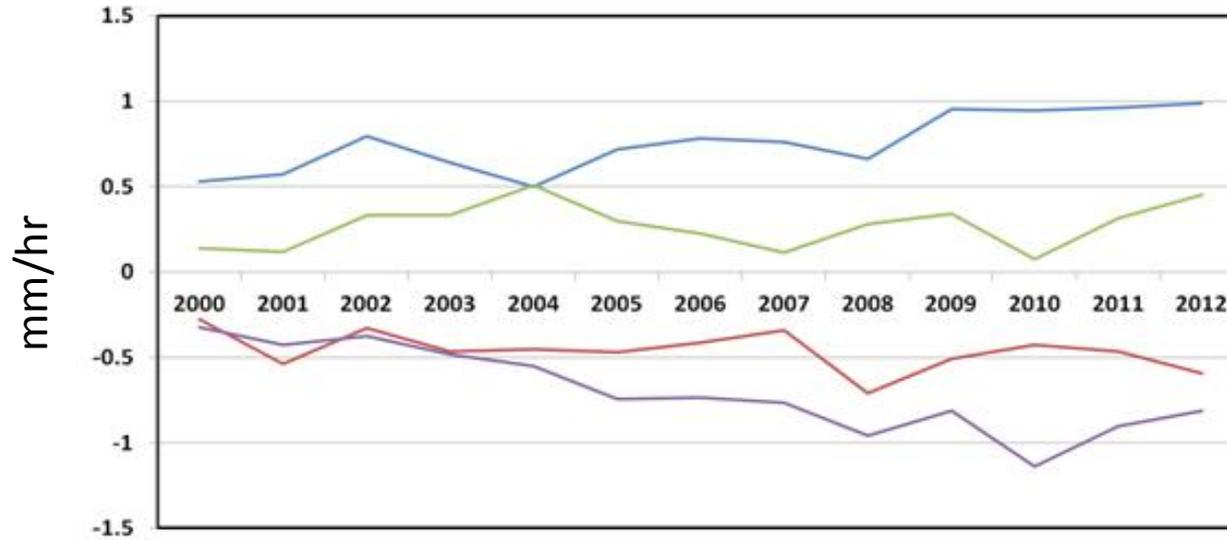


$$ME = \frac{1}{N} \sum_{i=1}^N (Y_i - O_i)$$

where,  $Y_i$  is the estimated value of 3B42RT and  $O_i$  3B42 at grid box  $i$ , and  $N$  is the total of samples.

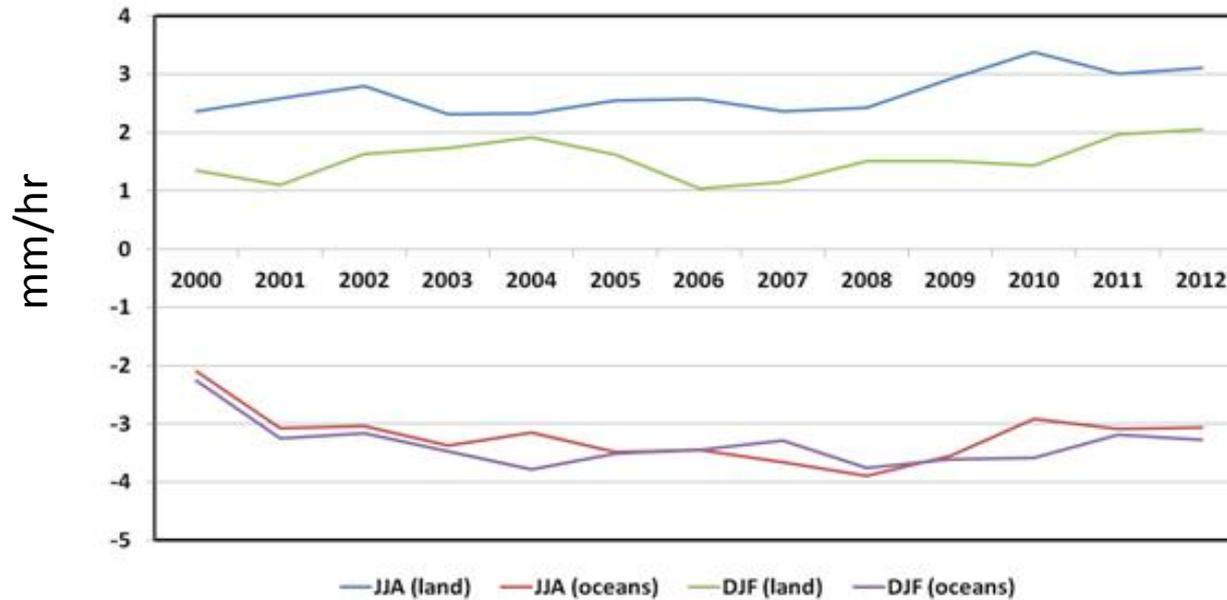
# Mean Seasonal ME

a)



Moderate Rain

b)



Heavy Rain

Moderate rain ( $2.5 \text{ mm/hr} < \text{rain rate} \leq 10 \text{ mm/hr}$ ) and heavy rain ( $10 \text{ mm/hr} < \text{rain rate} \leq 50 \text{ mm/hr}$ ) [Met Office, 2007]

# Top: ME (JJA, NH) Bottom: ME (DJF, SH) (mm/hr)

Year	Moderate Rain (land)		Moderate Rain (ocean)		Heavy Rain (land)		Heavy Rain (ocean)	
	Average	ME	Average	ME	Average	ME	Average	ME
2000	4.56	0.53 (11.6%)	4.31	-0.28 (-6.4%)	13.96	2.36 (16.9%)	12.36	-2.10 (-17.0%)
2001	4.51	0.57	4.35	-0.54	13.94	2.59	12.61	-3.07
2002	4.52	0.79	4.33	-0.33	13.80	2.80	12.78	-3.04
2003	4.53	0.64	4.32	-0.46	13.89	2.31	12.70	-3.38
2004	4.49	0.50	4.34	-0.45	13.89	2.32	12.69	-3.15
2005	4.51	0.72	4.33	-0.47	13.89	2.55	12.76	-3.48
2006	4.52	0.78	4.27	-0.41	13.82	2.57	12.75	-3.45
2007	4.52	0.76	4.27	-0.34	13.84	2.36	12.76	-3.65
2008	4.51	0.66	4.23	-0.71 (-16.7%)	13.73	2.42	12.68	-3.89 (-30.7%)
2009	4.53	0.95	4.25	-0.51	13.82	2.92	12.85	-3.54
2010	4.56	0.95	4.24	-0.43	14.04	3.38 (24.1%)	12.83	-2.91
2011	4.55	0.96	4.22	-0.46	13.82	3.00	12.65	-3.09
2012	4.52	0.99 (21.8%)	4.27	-0.59	13.74	3.10	12.69	-3.07

Year	Moderate Rain (land)		Moderate Rain (ocean)		Heavy Rain (land)		Heavy Rain (ocean)	
	Average	ME	Average	ME	Average	ME	Average	ME
2000	4.44	0.14	4.34	-0.32 (-7.44%)	13.74	1.35	12.50	-2.26 (-18.08%)
2001	4.48	0.12	4.32	-0.43	13.71	1.10	12.43	-3.25
2002	4.51	0.33	4.32	-0.38	13.68	1.63	12.53	-3.16
2003	4.51	0.33	4.32	-0.48	13.71	1.74	12.53	-3.47
2004	4.52	0.51 (11.22%)	4.34	-0.55	13.71	1.92	12.66	-3.79
2005	4.47	0.30	4.20	-0.75	13.74	1.62	12.53	-3.51
2006	4.47	0.22	4.19	-0.74	13.74	1.04 (7.59%)	12.64	-3.45
2007	4.47	0.11	4.20	-0.77	13.62	1.15	12.59	-3.29
2008	4.47	0.28	4.15	-0.96	13.62	1.50	12.49	-3.75 (-30.06%)
2009	4.50	0.34	4.19	-0.81	13.73	1.51	12.63	-3.61
2010	4.48	0.08 (1.70%)	4.11	-1.14 (-27.69%)	13.63	1.43	12.56	-3.58
2011	4.47	0.32	4.16	-0.90	13.70	1.97	12.57	-3.18
2012	4.45	0.45	4.18	-0.81	13.78	2.06 (14.91%)	12.66	-3.28

# Major Issue – Lack of Data

cawcr.gov.au/projects/SatRainVal/IPWG\_precip\_archive.html ipwg

## IPWG Precipitation Validation / Intercomparison Study

### Data Archive

*Project overview*

Several satellite precipitation algorithms are run operationally and semi-operationally from national centers and universities to produce rainfall estimates for time periods ranging from half-hourly to monthly. Many of these rainfall products are obtainable by the public via the web or FTP, and are being used for a variety of meteorological, climate, hydrological, agricultural, and other applications.

In order to use these rainfall estimates appropriately it is important to have an idea of their accuracy and expected error characteristics. This is done by validating the satellite precipitation estimates against "ground truth" from rain gauge and/or radar observations. To get good estimates of absolute accuracy satellite products should be verified against very high quality radar and gauge data (from the TRMM verification sites, for example). To get estimates of regional and spatial accuracy it is necessary to use a much larger quantity of data, for example, from national rain gauge networks.

*Data archive*

To facilitate the participation of the larger community, an archive of daily satellite precipitation estimates and surface reference data has been established at the Cooperative Institute of Climate Studies (CICS) at the University of Maryland. Included are IR, passive microwave, and combined microwave+IR satellite rainfall estimates from a large number of algorithms (see [Table 1](#)). Most of these satellite estimates have global or near-global coverage. Daily gauge analyses and radar analyses are provided for the continental U.S.; reference data for other regions may be added at a later date.

The archive starts in January 2004, with 24h accumulations valid at 00, 06, and 12 UTC. It is updated on a daily basis around midnight, USA Eastern Time.

The data are freely available via anonymous FTP:

- ftp server: **cics.umd.edu**
- user name: **anonymous**
- password: **<your e-mail address>**
- directory: **/pub/DATA/Validation/**

**No new data**

There are three subdirectories for 00Z, 06Z, and 12Z daily data. Due to space limitations on the server, only data from January 2006 onward are included in the directory listed above. Data from 2004 and 2005 are available from the same FTP server in directories [/pub/data1/old-data/IPWG2004](#) and [/pub/data1/old-data/IPWG2005](#), respectively.

Click [here](#) to download a PDF document giving a brief description of each dataset including information on the nature of the product, contact information, rainfall units, grid dimensions, starting point and spatial resolution, value for missing data, and GrADS control files. This document is also available on the FTP site given above.

Detailed documentation for some of the satellite algorithms and datasets can be found at the IPWG web site. <http://www.isac.cnr.it/~ipwg/algorithms/algorithms-invent.html>.

# Summary

- Online intercomparison tools for precipitation products (mainly TRMM and TMPA, 3-hourly, daily, monthly and climatology)
- Ongoing tool development for adding IPWG validation statistics
- Inputs from the IPWG community are very important for future work

# Future Plans

- Add more products and features in Giovanni-4
- Release the beta version of the IPWG tools
- GPM IMERG (Integrated Multi-satellitE Retrievals for *GPM*)

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# Thank you!

## URLs:

- TOVAS: <http://disc.sci.gsfc.nasa.gov/precipitation/tovas>
- Giovanni: <http://disc.sci.gsfc.nasa.gov/giovanni>
- GES DISC: <http://disc.sci.gsfc.nasa.gov/>

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